Climate Adaptation and Protected Areas Initiative

Climate Risk Profile: Greater Virunga Landscape

CAPA REPORT

Susan Sekirime
Enock Mwangilwa
Daniel Abowe

August 2026

Project partners

IISD International Institute for Sustainable Development

Wildlife Conservation Society

WWF

Funded by

In partnership with Canada

Published by the International Institute for Sustainable Development

Climate Adaptation and Protected Areas (CAPA) Initiative

The Climate Adaptation and Protected Areas (CAPA) Initiative seeks to promote nature-based solutions (NbS) to strengthen climate resilience and protect biodiversity in and around protected areas and critical ecosystems. The CAPA Initiative, funded by Global Affairs Canada, will work with local communities, traditionally underrepresented groups, women's groups, and national and local authorities in Belize, Fiji, the Greater Virunga Landscape, and the Kavango–Zambezi Landscape to implement site-specific activities that respond to the risks, vulnerabilities, needs, and priorities of local communities and ecosystems, as identified through comprehensive assessments of the climate, gender, biodiversity, and conflict contexts. The CAPA Initiative is led by the International Institute for Sustainable Development (IISD), the Wildlife Conservation Society (WCS), and the World Wide Fund for Nature (WWF).

To learn more, visit https://www.iisd.org/capa.

Climate Risk Profile: Greater Virunga Landscape

August 2026

Photo: Luke Katemba

Written by Susan Sekirime, Enock Mwangilwa, and Daniel Abowe

Edited by Emma Vovk

CAPA Initiative Project Partners

International Institute for Sustainable Development

The International Institute for Sustainable Development (IISD) is a globally recognized think tank with more than 30 years of experience working to solve today's greatest sustainable development challenges. We combine deep expertise across critical policy areas with a collaborative approach to research, advice, and hands-on support that delivers real-world results. Headquartered in Winnipeg, Manitoba, we are a diverse team of over 300 experts working from offices in Canada and Switzerland as well as other locations around the world.

IISD's headquarters in Winnipeg are situated on Treaty 1 Territory—the ancestral lands of the Anishinaabe (Ojibwe), Ininiw (Cree), Anisininew (Ojibwe Cree), Dene, and Dakota Nations, and the homeland of the Red River Métis Nation.

IISD is a registered charitable organization in Canada and has 501(c)(3) status in the United States. IISD receives core operating support from the Province of Manitoba and project funding from governments inside and outside Canada, United Nations agencies, foundations, the private sector, and individuals.

Head Office

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

Website: iisd.org
X: @IISD_news

Wildlife Conservation Society

The WCS is an international non-governmental organization committed to working with communities, governments, and other partners to safeguard biodiversity and natural resources through integrated land and seascape management underpinned by applied research. We run programs spanning the entire ocean and more than 3 million biologically critical square miles in nearly 60 countries. The CAPA Initiative is working with WCS Belize, WCS Fiji, and WCS Central.

Head Office

2300 Southern Boulevard
Bronx, New York
USA 10460

Website: wcs.org
X: @thewcs

World Wildlife Fund

WWF is an independent conservation organization with a global network in over 100 countries that collaborates with people at all levels to develop and deliver innovative solutions that protect wildlife and communities. Our mission is to stop the degradation of the planet's natural environment and to build a future in which people live in harmony with nature. The CAPA Initiative is working with WWF Uganda, WWF Zambia, WWF Africa, and WWF International.

Head Office

1250 24th Street, N.W.
Washington, DC
USA 20037

Website: worldwildlife.org
X: @world_wildlife

Table of Contents

List of Figures

List of Tables

List of Boxes

Abbreviations and Acronyms

CAPA	Climate Adaptation and Protected Areas
CORDEX	Coordinated Regional Climate Downscaling Experiment
GESI	gender equality and social inclusion
GVL	Greater Virunga Landscape
GVTC	Greater Virunga Transboundary Collaboration
GWL	global warming level
IOM	International Organization for Migration
IPCC	Intergovernmental Panel on Climate Change
NAP	national adaptation plan
NDC	nationally determined contribution
NbS	nature-based solutions
SSP	shared socio-economic pathway
WWF	World Wildlife Fund

1.0 About the Climate Risk Profile

The Climate Adaptation and Protected Areas (CAPA) Initiative seeks to promote natural solutions to strengthen climate resilience and protect biodiversity in and around protected areas and critical ecosystems in Belize, Fiji, and the Greater Virunga Landscape (GVL) and Kavango-Zambezi Landscape in Africa. Within this 3-year project, the International Institute for Sustainable Development, in collaboration with conservation partners at the Wildlife Conservation Society and the World Wildlife Fund for Nature (WWF), local communities, traditionally underrepresented groups such as women and Indigenous Peoples, and national and local authorities, are designing and implementing nature-based solutions (NbS) for adaptation in and around protected areas and critical landscapes in the Global South, and working to better integrate climate risks into the management of these spaces. The project is implemented with financial support from Global Affairs Canada.

Box 1. What are NbS for adaptation?

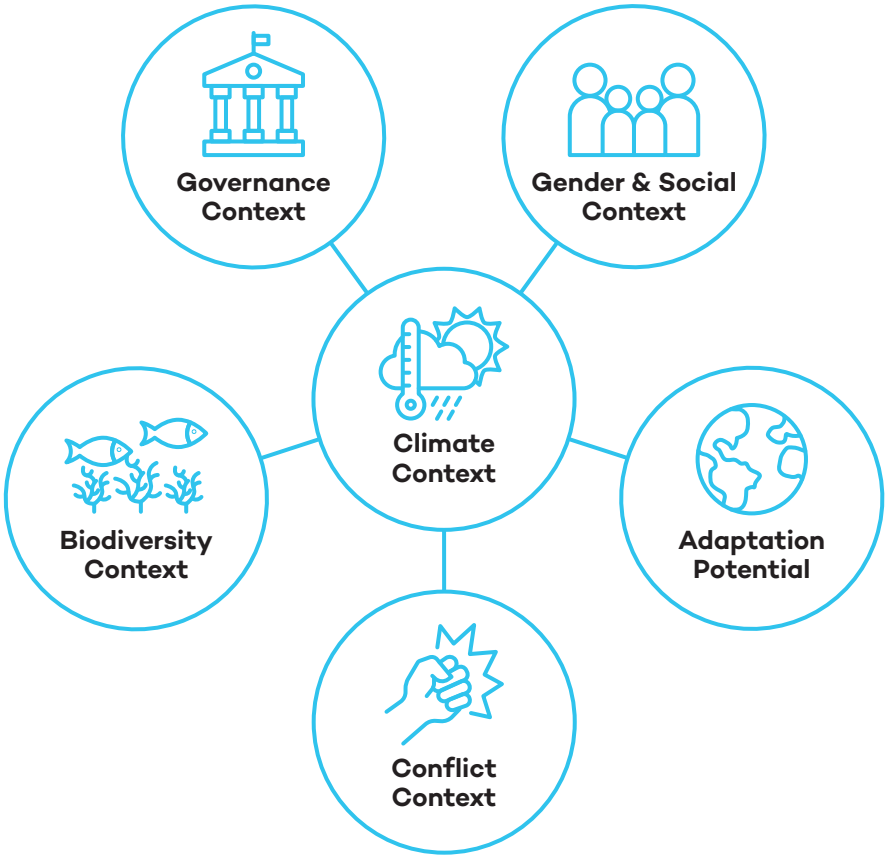
NbS for adaptation are actions to protect, conserve, restore, sustainably use, and manage natural ecosystems to strengthen the resilience of communities and ecosystems to the impacts of climate change (adapted from UNEA, 2022). They involve assessing how climate change will affect ecosystems and people of all genders and social backgrounds and identifying how ecosystems can help to address these impacts on people.

As part of this project, the CAPA Initiative has developed a set of climate risk profiles for each of the four target Landscapes to illustrate the impacts of climate change within and around select protected areas and critical ecosystems. The profiles are based on the comprehensive climate risk and vulnerability assessment undertaken by the project in 2024, which informed the choices of NbS for adaptation and the gender equality and social inclusion (GESI) strategies implemented by the project across the four target landscapes.

The assessment, which explored six thematic areas (see Figure 1), relied on observed and projected climate change impacts reported by communities, local government, and protected area officials, as well as climate data from the European Centre for Medium-Range Weather Forecasts' ERA5 atmospheric reanalysis (Hersbach et al., 2020), climatic projections derived from the Intergovernmental Panel on Climate Change (IPCC) Working Group I Interactive Atlas (IPCC, n.d.; Gutiérrez et al., 2023), and the Coordinated Regional Climate Downscaling Experiment (CORDEX) regional climate model for Africa (Giorgi et al., 2009).

The GVL climate risk profile provides an overview of the GVL climate context, as well as a set of NbS for adaptation actions and measures that can be implemented in the landscape.

Figure 1. Six themes explored as part of the integrated climate risk assessment



Source: Jang et al., 2025.

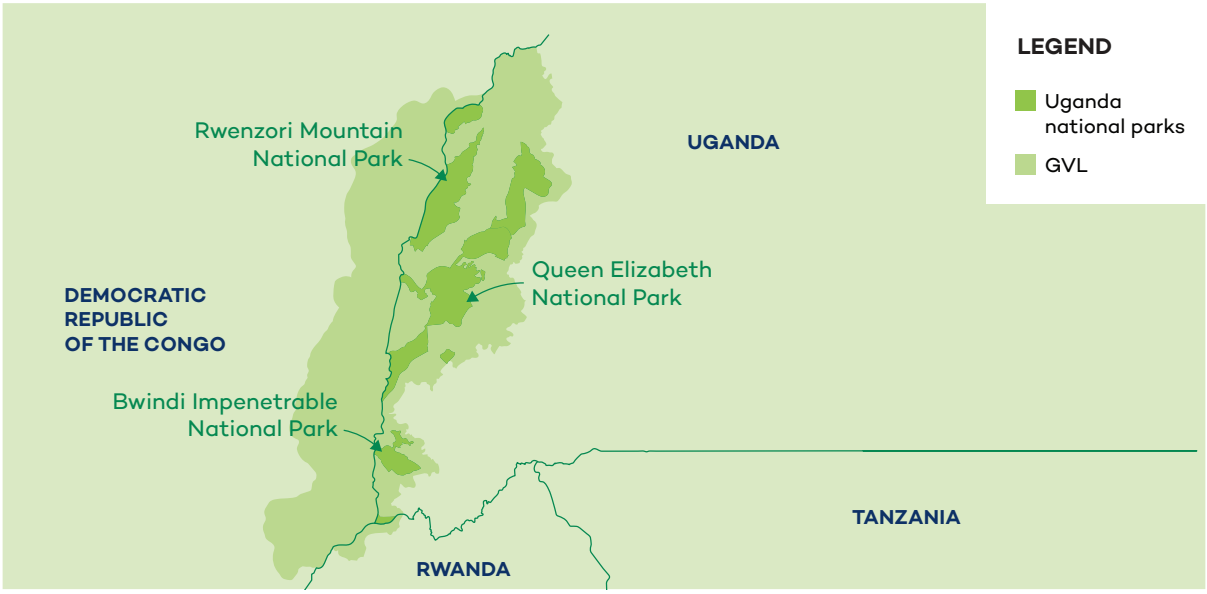
1.1 The GVL

The GVL straddles the borders between the Democratic Republic of the Congo, Rwanda, and Uganda, and is among the most biodiverse places on Earth, with immense ecological, socio-cultural, and potential economic value (Plumptre et al., 2007). In 2015, the three countries formalized the Greater Virunga Transboundary Collaboration (GVTC), which aims to coordinate the sustainable conservation of the landscape's biodiversity and associated socio-cultural values across its network of protected areas (GVTC, 2015).

The comprehensive climate risk assessment for the GVL was conducted in three sites in western Uganda, in and around the critical ecosystems and protected areas in the GVL: Kisoro, near Bwindi Impenetrable National Park; Rubirizi, near Queen Elizabeth National Park; and Kasese, near Rwenzori Mountains National Park (see Figure 2). The surrounding area is densely populated, with close to 4.3 million people living around the three sites. An estimated 800,000 people live in Kasese, 315,000 in Kisoro, and 144,000 in Rubirizi, according to the Uganda Bureau of Statistics (2020). The assessment gathered information from the following communities located in or buffering the protected areas: Nyambuku in Kasese, Nyabaremura and Kirengeri in Kisoro, and Ahankungu in Rubirizi.

The GVL is a highly variable landscape geologically and geographically, with altitudes ranging from 600 m above sea level in Semuliki National Park in the north, to 5,109 m in the central Rwenzori Mountains National Park. Covering an area of 26,663 km^2, of which 13,800 km^2 is in protected areas (Plumptre et al., 2007), the GVL divides the Congo and Nile River basins and their watersheds, forming one of the largest and most important "water towers" in Africa. The landscape includes eight national parks and other game and forest reserves that collectively contain more terrestrial, endemic, and threatened vertebrate species than any other defined landscape in Africa (Plumptre et al., 2007). Within its boundaries, ecosystems range from ancient tropical forests, glacier-capped mountains, and active volcanoes to savannah, grassland, and wetlands.

Figure 2. A map of the GVL boundary and CAPA Initiative sites in Uganda



Source: CAPA Initiative.

Forests in the GVL provide habitats for large and globally important populations of African ungulates, hippopotamus, and 20 co-existing primate species, including the entirety of the world's remaining mountain gorillas, as well as rare birds and plants. Lake Edward and Lake George, within the same landscape, are two of Africa's most productive lakes, with socio-economically important fisheries and many endemic fish species.

Rwenzori Mountains National Park, a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site, is a critical component of the region's water tower system that provides fresh water to numerous lakes and rivers, including Lake George and Lake Edward, and the Nile and Semliki rivers. The park is home to over 100 species of mammals, with more than 15 endemic to the western branch of the East African Rift system—the Albertine Rift—including key species such as the eastern chimpanzee and the three-horned chameleon. Queen Elizabeth National Park, a UNESCO Man and the Biosphere Programme reserve, spans 1,978 km^2 of savanna landscape and is intersected by several watercourses. It boasts abundant wildlife, including over 600 bird species. In the south,

Bwindi Impenetrable National Park covers 321 km^2 of primary forest habitat and is home to nearly half of the world's mountain gorillas (Uganda Wildlife Authority, 2014), as well as other mammals, such as forest elephants and eastern chimpanzees. The larger Bwindi Mgahinga Conservation Area, which also encompasses Mgahinga Gorilla National Park, is historically inhabited by the Indigenous Bakiga, Bafumbira, and Batwa or pygmies, each with their distinct languages.

2.0 Climate Context in the GVL

The overall climate in the GVL can be defined as tropical rainforest and tropical savanna (Climate Change Knowledge Portal, 2026). However, the widely variable altitudes and habitat types in the landscape create distinct sub-climates and ecological niches across different sites (WWF, 2021). The GVL has two wet seasons, lasting from August to November and March to May. Average annual rainfall between 1990 and 2020 ranged from 1,500 mm in Rubirizi (measured in Queen Elizabeth National Park) to 2,360 mm in Kisoro (measured in Bwindi National Park), reaching 3,640 mm in Kasese (measured in Rwenzori Mountains National Park) (Climate Change Knowledge Portal, 2026). Mean annual air temperatures for the landscape range from 20°C to 23°C (Kenfack, 2013) and reach lows in July.

2.1 Observed Climatic Changes

Based on the climate vulnerability assessments conducted in 2020, the landscape has been experiencing increasing rates of annual precipitation and temperature, accompanied by more frequent heat waves (WWF, 2021). Alongside this, communities living within the GVL are impacted by a range of climate change-related hazards and risks, including drought, wildfires, flooding, landslides, and soil erosion. While the severity of climate-related risks experienced by residents varies across the landscape, 85% of households are exposed to droughts. Flooding and mudslides were recorded in 2013 near Queen Elizabeth National Park (Kasese) (United Nations Office for the Coordination of Humanitarian Affairs, 2014), and every year from 2021 to 2024 in Kasese and Kisoro districts (International Organization for Migration [IOM] Uganda, 2024; United Nations Office for the Coordination of Humanitarian Affairs, 2022, 2023, 2024, 2025; United Nations Women, 2022).

For the period 1980–2015, the following trends have been observed using ERA5 data: in Kasese,[1] total annual rainfall decreased by 181 mm per decade, and the mean and maximum air temperatures have risen by 0.14°C and 0.24°C per decade, respectively. In Kisoro, total annual rainfall has declined by 96 mm per decade. Air temperatures typically range from minimums of 7°C–15°C to maximums of 20°C–28°C (Uganda Wildlife Authority, 2014), and the mean and maximum temperatures have increased by 0.12°C and 0.21°C per decade, respectively.

[1] Due to the resolution of ERA5 climatic observation data and of the CORDEX-Africa models used, data for Kasese District also encompasses Rubirizi District.

2.2 Future Climate Projections

For the GVL, the IPCC models predict a high-confidence estimate of increased mean surface temperatures, extreme heat, heavy precipitation rates, and floods, and a marked decrease in cold spells. For the period 2040–2060, total annual precipitation across the region is expected to rise by 1.9% relative to historical 1960–1990 rates, and mean annual temperatures are expected to increase by 2.7°C (13%). The rainy season from August to November is expected to get wetter, alongside an increased risk of flash floods and landslides, while the second rainy season, lasting from March to May, is predicted to get slightly drier, in line with observed changes over the past 30 years.

The variable topography in the landscape can create complex climate gradients and significantly influence local climatic conditions. Based on the IPCC's interactive Atlas and CORDEX-Africa regional climatic model, the following projections are estimated for Kisoro and Kasese over the next century (IPCC, n.d.; Giorgi et al., 2009; Gutiérrez et al., 2023). These are illustrated in Figure 3 and further detailed in the Appendix.

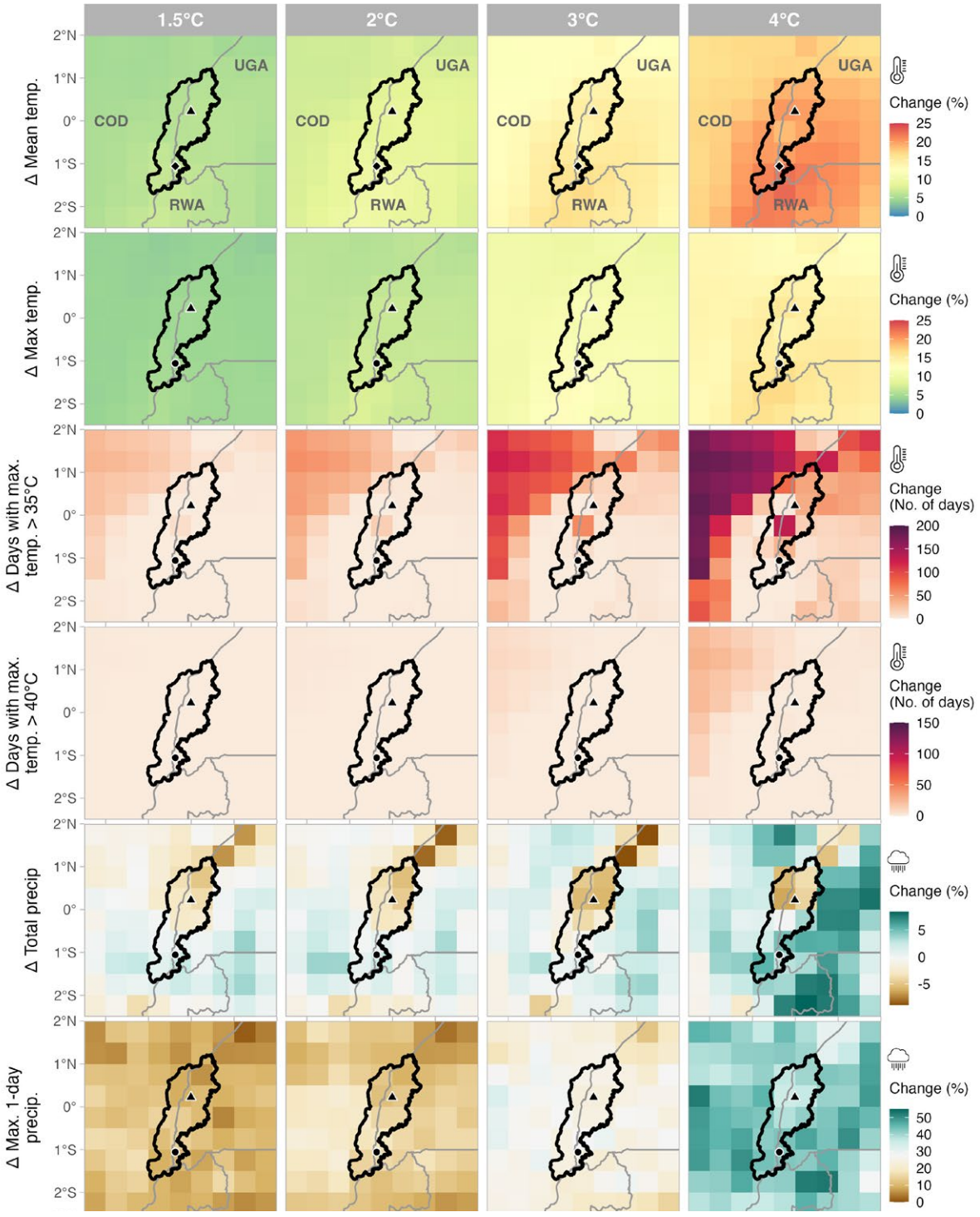
- **A rise in air temperatures within the next century**: Both Kisoro and Kasese are projected to experience mean temperature rises from approximately 6% at 1.5°C to 9% at 2°C global warming levels (GWLs). The mean daily maximum temperature will increase similarly, with projected increases up to 7% under 2°C warming. Despite these increases, the number of days with maximum temperatures above 35°C and 40°C remains stable, with only slight increases at the highest warming levels.

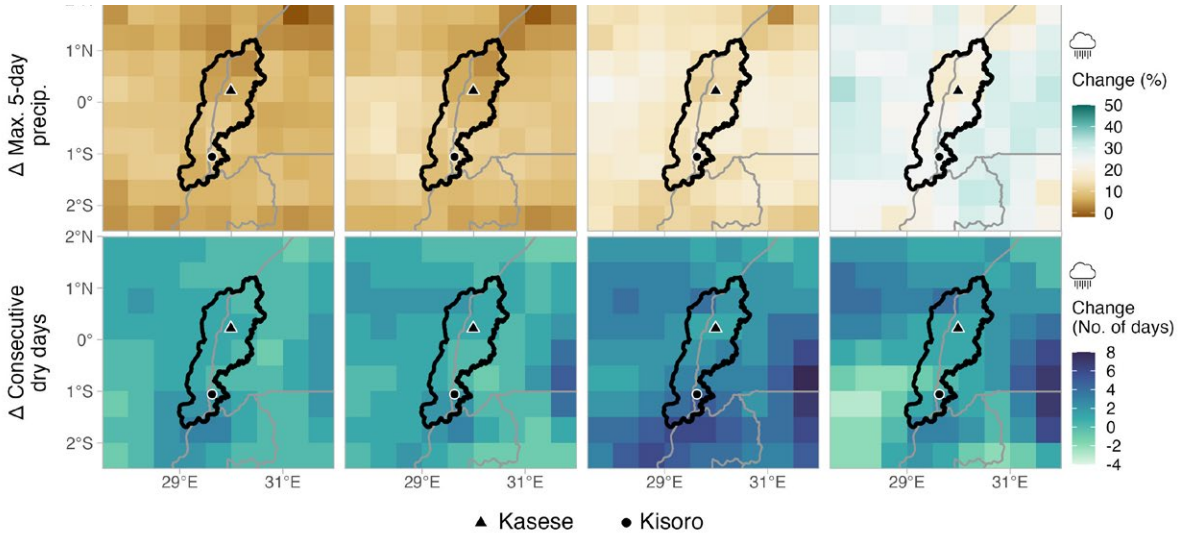
  The projected rise in temperature will increase heat stress in human and natural systems across communities. Although the number of extreme heat days is projected to remain stable, increases in mean and maximum temperatures can affect agriculture and biodiversity.
- **Changing precipitation patterns**: The annual precipitation data showed a mixed trend. Kisoro is projected to see a slight increase (2.6%) in precipitation at the 1.5°C warming level, a slight decrease at 2°C and 3°C, and an increase for the 4°C GWL. Total precipitation in Kasese is projected to consistently decrease for all GWLs throughout (-3% at 1.5°C) and continue decreasing for subsequent GWLs across all warming levels. The mixed trends in annual precipitation and increases in concentrated rainfall events suggest greater variability in water availability. This increased variability will exacerbate the impacts of higher temperatures in the region.
- **An increase in heavier rainfall events**: Throughout the landscape, concentrated precipitation events, including maximum 1-day and 5-day precipitation events, are expected to become more intense. At 2°C warming, the average increase in maximum 1-day precipitation is 15% in Kisoro and 11% in Kasese.

  The projected increase in maximum 1-day and 5-day precipitation events, together with the reduced rainfall amount for Kasese, suggests an increased risk of flash floods and drier conditions, which will raise the risk of mudslides. This will have negative impacts on crop production and human life, as the current impacts of mudslides are severe. Severe mudslides are already affecting the landscape (IOM Uganda, 2024).

- **Slightly longer dry spells**: The maximum number of consecutive dry days is projected to remain stable, which may help reduce drought risks despite the overall decline in precipitation at higher warming levels. This trend is expected to be milder in Kasese and Rubirizi.

Figure 3. Projected climate change under four different GWL scenarios (1.5°C, 2°C, 3°C, and 4°C) for CAPA Initiative sites in the GVL





Source: IPC, n.d.; Giorgi et al., 2009.

3.0 Observed Climate Hazards and Risks in the GVL

The communities in Kasese, Kisoro, and Rubirizi have experienced notable climate change impacts, including rising temperatures, extended dry spells, climate and rainfall variability, and extreme weather events. These changes have significantly affected their livelihoods by reducing potable water supply, increasing health issues due to pests, decreasing crop yields, and causing food insecurity. Table 1 outlines the observed climate hazards and their associated risks to residents in the GVL.

Box 2. Definitions

Climate hazard: climate-related events or trends that may result in loss and damage to lives, health and well-being, livelihoods, infrastructure, ecosystems, and natural resources (IPCC, 2023). The onset of climate hazards can be slow (e.g., temperature rises) or rapid (e.g., storms).

Climate risk: the potential for climate change to create negative consequences for societies and ecosystems. This includes impacts on "lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services, ecosystems, and species" (IPCC, 2023).

Table 1. Climate hazards and associated risks in the GVL

Climate hazards	Climate risks
Rising temperatures	• Declining availability of potable water during the dry seasons • Increasing heat stress and heat-related illnesses for people and livestock • Increased incidence of vector-borne diseases such as malaria, which are linked to higher temperatures and precipitation
More frequent and prolonged dry spells	• Reduced quality of crop yields and greater likelihood of mid-season crop failures, leading to food insecurity • Reduced pasture availability for livestock
Increased frequency and severity of mudslides (particularly in Kisoro and the highlands of Kasese)	• Higher risk of death and injury • Displacement of communities • Destruction and damage to infrastructure, homes, crops, and livestock • Reduced quality and availability of potable water

Climate hazards	Climate risks
Increased rainfall	• More conducive environment for pests and vector populations, and associated increase in malaria cases • Soil erosion and runoff affecting soil productivity
Flooding (particularly in valley farming areas)	• Heightened risk of soil erosion • Damage to valley crops and gardens, and associated food and economic insecurity • Loss of household assets and farmland • Contamination of local water supply
Drought	• Increased occurrence of successive years of drought • Stress on people, flora, and fauna • Reduced availability of fodder and pasture for livestock • Diminished crop yields and associated food insecurity • Reduced availability of potable water • Associated increase in flash floods due to hardened ground
Increased occurrence of consecutive storms (particularly in Kisoro and Kasese)	• More frequent associated hazards such as flash floods and mudslides • Destruction and damage to crops, homes, and livestock, and associated economic losses • Displacement of communities
Erratic precipitation and temperature patterns	• Less predictable seasons resulting in agricultural calendars becoming difficult to manage, and higher likelihood of crop failure • Changes to food and water availability (e.g., shortages) • Reduced pasture availability for livestock

Source: Fieldwork data.

4.0 Climate Change Impacts on Ecosystems and Communities

4.1 Present and Projected Climate Change Impacts on Ecosystems

Climate change greatly affects ecosystems and can exacerbate biodiversity loss. Across the three national parks, there has been an increasing trend in wild animals moving beyond park boundaries due to climate hazards that reduce the suitability of their habitats and availability of food and water. This has contributed to frequent incidences of human–wildlife conflict in all assessed communities. Poaching also occurs in response to heightened food insecurity caused by more frequent droughts. Further, all three national parks have recorded increasing numbers of invasive species as changing climates allow these species to thrive and out-compete native flora.

Projections of two Shared Socio-economic Pathways' (SSPs') increased greenhouse gas emissions scenarios (low: SSP1–2.6 and intermediate: SSP2–4.5) estimate that the suitability of habitats for key species in the GVL will decline by 2050. Gorilla habitat suitability is projected to decline sharply by 2030 and steadily thereafter. In Kasese and Rubirizi, habitat suitability for chimpanzees is projected to show no change by 2030 but is projected to decrease by 2050 under a low-emissions scenario. Under intermediate emissions, habitat suitability for chimpanzees and olive baboons also decreased, but showed a slight recovery by 2050. Table 2 outlines the observed impacts of climate change on biodiversity and ecosystems in Bwindi Impenetrable National Park, Rwenzori Mountains National Park, and Queen Elizabeth National Park.

Table 2. Current and projected impacts of climate change on ecosystems

Climate hazards	Impacts	Description
Increasing temperatures	Melting snow and ice caps on mountains	Increased warming has caused the snow and ice caps on the peaks of Rwenzori Mountains National Park to melt, which can exacerbate the risk of floods and biodiversity loss and degrade forest ecosystems and resources. Higher temperatures negatively impact the survival of bamboo and other vegetation species, with observed changes in physiological characteristics across the assessed sites.
	Biodiversity loss	
	Changes in forest composition	
	Expansion of invasive species distributions	As the climate gets hotter, it creates conditions for invasive species to thrive within protected areas. The shift in plant species diversity is projected to reduce the availability of food species for gorillas and other fauna. In Bwindi Impenetrable National Park (Kisoro) and Queen Elizabeth National Park (Rubirizi), warming has increased evapotranspiration, consequently reducing the amount of water available in forage plant species for gorillas. In Kisoro, gorillas have been observed moving away from protected areas in search of water. The trend of increasing evapotranspiration is projected to worsen.
	Changes in food availability and range shifts for gorillas	
Droughts and dry spells	Increased animal migration	Decreasing habitat suitability and availability of food and water resulting from increased temperatures and droughts has driven and will continue to drive wildlife out of protected areas to search for food and water closer to populated areas. Communities in the GVL already experience incidents in which elephants and gorillas destroy crops in gardens and fields. Drought-induced food insecurity also leads to increased levels of poaching.
	Human–wildlife conflict	
	Increased poaching	
	Slow regeneration of ecosystems	Changing temperatures, longer droughts, and reduced water availability reduce vegetation and pastureland's ability to regenerate.
	Deterioration of swamp and wetland ecosystems	Wetlands and swamps are increasingly exposed to dry spells and droughts, causing them to dry up. The deterioration of these ecosystems contributes to water scarcity and affects connected water systems, such as lakes, which rely on wetlands for flood control.
	Biodiversity loss	There has been a marked decline in bird observations in Kisoro.

Climate hazards	Impacts	Description
Changing precipitation patterns and mudslides	Increased soil erosion and runoff	Increased rainfall escalates runoff, thus contributing to soil erosion that can be exacerbated by increased land-use changes (e.g., exposed ground surfaces in areas surrounding communities in Kisoro). Mudslides that reach rivers contribute to siltation in these water systems, thereby contaminating water resources and reducing rivers' hydrological discharge capacity across the landscape. Declining rainfall and pollution of water resources from flooding and mudslides lead to a strong reduction in freshwater resources across GVL ecosystems.
	Contaminated water supply	
	Reduced availability of fresh water	

Source: Fieldwork data.

4.2 Present and Projected Climate Change Impacts on Communities and Livelihoods

Climate change significantly impacts the livelihoods of communities in the GVL, which are highly dependent on natural resources and therefore vulnerable to climate hazards. The majority of people living in the landscape are small-scale landholders whose livelihoods rely mainly on crops and livestock, with forest products, fishing, and tourism also contributing. Fishing in the landscape's rivers and lakes, including Lake Edward and Lake George, is the main livelihood sector for around 20% of households (GVTC, 2024).

The observed climatic changes have had widespread impacts on the key livelihood sectors and assets in Nyabaremura and Kirengeri (Kisoro), Nyambuku (Kasese), and Ahankungu (Rubirizi) communities. The assessment found that climate change impacts affect the same critical livelihood assets across all four communities:

- **Financial**: Community members have reported that drought, floods, and mudslides have negatively impacted their sources of income. Such climate hazards damage or destroy key assets such as crops, leaving no surplus produce for sale. These losses result in higher dropout rates from school, as households do not have readily accessible money to support school-related expenses in addition to fulfilling fundamental food security needs. An increase in the number of rainy days directly impacts income generated from local sand and stone quarrying businesses. Climate change also indirectly impacts financial health, with reports of farmers being unable to pay back loans and accruing debt as a result of reduced yields.
- **Water**: The scarcity of critical water resources, including river flows, due to more frequent droughts, has forced community members, usually women and girls, to spend more time and travel farther distances to collect potable water. Some women have suffered animal attacks on these journeys, thus endangering their lives in the process of managing household water resources. Increasingly intense mudslides and floods

have contributed to water scarcity by contaminating freshwater sources and physically blocking water points.

- **Health**: All four communities reported experiencing higher rates of malaria during the rainy seasons and are projected to be at a heightened risk of cholera and diarrhea due to contaminated water supplies after flood events. Furthermore, women, especially those who are pregnant, face reduced access to health facilities during floods, and locally harvested or cultivated herbal plants used as alternative medicines are at risk of destruction from extreme rainfall and storms.
- **Socio-economic**: The four communities have suffered devastating losses of life and infrastructure caused by mudslides, and drought-induced food shortages have led to increases in gender-based violence. Alongside the higher school dropout rates arising from income loss, there is an increase in absenteeism among school-going children due to rain-swollen river flows that block their access to schools.
- **Infrastructure**: Floods and mudslides destroy key infrastructure services, including roads and bridges, and ultimately affect the movements of people and resources toward health care facilities, markets, schools, and workplaces. These impacts are expected to worsen as these extreme events intensify.
- **Energy**: The energy supply of households is vulnerable during the rainy seasons, as the increased rainfall makes collecting firewood more difficult.

Table 3 shows some of the impacts on key livelihood sectors in the four communities.

Table 3. Climate impacts on livelihood sectors

Livelihood sector	Climate hazard	Climate impact
Agriculture	• Droughts • Increasing climatic variability • Increasingly intense mudslides	Decreasing agricultural productivity and reduced crop yields, including crop failure, and significantly increased food insecurity.
		Increased risk of crop destruction in agricultural areas, which are usually located on hills and are therefore highly exposed to mudslides. Reduced yields impact food security.
Livestock	• Mudslides	Affected grazing areas reduce the availability of pasture for livestock. Mudslides lead to a higher death rate for livestock, with an increased number of animal deaths observed in Kisoro. As the frequency and intensity of mudslides increase, livestock mortality in Kisoro and neighbouring districts is expected to increase.
	• Droughts	Reduced access to water for livestock.

Livelihood sector	Climate hazard	Climate impact
Fishing	• Mudslides	The increased pollution of water sources from mudslide deposits affects aquatic biodiversity and ecosystems and reduces fishing catches.
Tourism	• Drought • Increased warming	Decreasing availability of natural resources used for crafting and tourism-related income. The reduced suitability of habitat for key wildlife species is also projected to impact the income from tourism, with Queen Elizabeth National Park most affected (a projected 40% decline in visits by 2050 [WWF, 2021]).

Source: Fieldwork data.

4.3 Present and Projected Climate Change Impacts on Different Genders and Underrepresented Groups

The impacts of climate change are not experienced equally by community members, and depend, rather, on their gender and other social identity factors. In the GVL, women and underrepresented groups such as Indigenous Peoples, people with disabilities, and youth are more strongly affected by certain climate impacts than men. For example, scarcity of food and potable water caused by more frequent droughts and mudslides will disproportionately impact women and girls who are typically responsible for food provision and household water management. People with disabilities, the elderly, and pregnant people are also highly vulnerable in water-scarce situations and face reduced access to health-care facilities during floods.

Box 3. The intersection of conflict, gender, and climate change

When examining the impacts of climate change on communities and ecosystems, it is important to consider the relationship between climate change and conflict. Climate change can cause or exacerbate conflict, and existing conflict can increase the vulnerability of certain populations and ecosystems to climate change.

Human–wildlife conflict has been observed in the communities surrounding the national parks as climate change exacerbates biodiversity loss and degrades habitat suitability. This has led to more frequent incidents in which crops and infrastructure are damaged by animals that have been driven out of the protected areas in search of food and water. Communities in the GVL reported that compensation for these losses is often inadequate. They noted further tensions are created by restrictions on accessing parks for natural resources such as firewood and medicinal plants, and a perceived unfairness in the distribution of benefits from ecotourism-related revenue.

The impacts of climate change have also driven youth and men to engage in illegal alternative livelihood activities, such as charcoal production, illegal mining, fishing, and poaching, among other activities. There are also instances of spillover effects from co-occurring conflicts in the eastern parts of the Democratic Republic of the Congo, which result in migration and increased pressure on already scarce resources.

Moreover, increasingly frequent floods and mudslides have important consequences on the number of internally displaced persons (IOM Uganda, 2024), following the destruction of homes and livelihoods. Women are distinctly more vulnerable than men in these situations, due to a variety of factors ranging from socio-cultural norms that prevent them from easily leaving households and unwillingness to leave dependent family members behind, low digital literacy restricting their access to early warning systems, and ultimately from gender-based violence along the forced migration route (United Nations High Commissioner for Refugees, 2022).

Livelihood activities in the GVL are shaped by gender and social norms. For example, in Kisoro, while both men and women engage in agricultural practices, decisions are made by the landowners, who are usually men. Livestock are also typically owned and herded by men, who are therefore impacted by climate change hazards that affect livestock production and health. Women were found to engage more in activities that require little land, such as mulching in gardens and terracing to aid in landslide control. Women also tend to be more involved in climate-sensitive livelihood sectors than men, who have more access to paid work. Indigenous Peoples such as the Batwa are also highly vulnerable to climate change, as they face difficulties in accessing agricultural land and natural and forest resources: prior to the gazetting of national parks, they subsisted on hunting and gathering. The assessed vulnerability of livelihoods to climate impacts across genders and underrepresented groups is as follows:

- **Crop farming**: This is the primary livelihood sector for households across the assessed communities in the GVL landscape. Crops are primarily rainfed, which increases exposure to crop failure associated with climate change. In Kisoro's Nyabaremura and Kirengeri communities, the main crops grown are beans, sweet potatoes, plantains, sorghum, maize, other vegetables, Arabica coffee, and sunflowers. Kasese's Nyambuku community and Rubirizi's Ahankungu community grow sugarcane in addition to the crops grown in Kisoro. All genders are involved in crop farming, and high female participation was reported, with women spending more time in the fields, thus exposing them to drought impacts and crop failure.
- **Water**: In Kisoro, residents depend mainly on surface water resources, with little access to groundwater. Increased pollution due to climate hazards such as mudslides has reduced water access in communities there. In Kasese, water is supplied from both surface and groundwater resources, including dams, perennial rivers, wetlands, and swamps. The perennial rivers are key for crop irrigation and for livestock rearing. Surface water resources are susceptible to drying up with increasing temperatures, a lack of rainfall, and more frequent droughts. Women are typically in charge of water collection and household water management, and water shortages can cause them to spend more time, and travel longer distances, to reach diminishing water sources.

- **Ecosystem services**: Communities in Kisoro and Kasese are endowed with natural resources from local ecosystems, mainly forestry, swamps, herbs, and minerals, all of which support their livelihoods and incomes. A lack of livelihood diversification available to women means that they are usually more involved in this form of natural resource collection. Creating crafts from these resources to sell to tourists is a common activity, though projected declines in tourist visits due to increased drought and temperatures put this sector at risk.
- **Community gardens**: These are critical in bolstering households' food security, chiefly through highly nutritious horticultural products, and for household-level climate adaptation. Across the four communities, women-led vegetable gardens were found to provide additional income and nutrition, reduce social isolation, and achieve greater self-reliance and community respect. However, climate hazards such as mudslides and floods heighten the vulnerability of garden workers' livelihoods.
- **Community-based tourism and conservation**: Gorilla trekking in and around Bwindi Impenetrable National Park, including Buhoma, Ruhija, Rushaga, and Nkuringo areas, is a large tourism business, attracting other developments to communities that help achieve resilience. With the projected decline in gorilla habitat suitability, tourism-related income will also be reduced, thus impacting men's livelihoods as rangers and guides, and women's selling artifacts and crafts. In Kasese, locally rich biodiversity supports community-based tourism and provides social benefits that are shared among the communities. Projected declines in rainfall and increased temperatures in this area of the GVL will affect the natural resources these sectors rely on.
- **Livestock**: In all four communities, livestock production is a key male-dominated livelihood sector, owing to cultural and societal constructs that favour ownership of livestock and land by men. Increasing mudslides and floods have affected livestock production, thereby increasing the vulnerability of men working in this sector.
- **Fishing**: This is an important sector in both Kisoro and Kasese, with fish contributing to food security and providing a source of income. Due to societal norms, men's participation is higher, as fishing is viewed as part of a man's role. The increased pollution of water sources from mudslides affects aquatic biodiversity and fish populations, consequently reducing catches.

4.4 Underlying Drivers of Vulnerability

Various underlying non-climatic drivers increase communities' vulnerability while reducing their adaptive capacity in assessed sites in the GVL. This capacity to cope with the impacts of climate change can either increase or decrease relative to the availability of physical, financial, and social assets. The identified drivers cut across the dependence on climate-sensitive livelihoods to inadequate infrastructure, and include the following:

- **Cultural and societal constructs**: Some gender-specific roles and responsibilities limit diversification of livelihoods and curtail women's decision-making power. For example, in Kasese, livestock production is predominantly managed by men due to cultural norms, precluding women from engaging in the necessary activities, and leaving them with fewer livelihood options.
- **Dependence on natural resources**: An over-reliance on forestry, herbs, and minerals for income, all of which are affected by climate change, increases these livelihoods' vulnerability. In Nyabaremura (Kisoro), the reliance on natural resources for crafting and tourism income is threatened by increased drought and higher temperatures.
- **Limited livelihood diversification**: Residents in the four communities have few local opportunities for economic diversification, making them vulnerable to climate impacts on the climate-sensitive sectors they rely on, such as rainfed agriculture.
- **Inadequate infrastructure**: Poor infrastructure exacerbates the impacts of climate hazards on communities. In Kirengeri (Kisoro), insufficient road infrastructure worsens the impact of mudslides on transportation.
- **Inadequate information on disaster risk management**: Limited knowledge and awareness about disaster preparedness and risk management strategies increase risks to residents. For instance, in Nyambuku (Kasese), the lack of disaster risk information leaves the community unprepared for mudslides.

4.5 Vulnerability Ranking of Assessed Communities

Following the IPCC's (2023) definition of vulnerability, the combination of exposure and sensitivity to climate shocks determines the potential overall impact of climate change. The difference between impact and adaptive capacity then determines vulnerability.

According to the Notre Dame Global Adaptation Initiative's Country Index, which evaluates a country's current vulnerability to climate disruptions and its readiness for adaptation, Uganda is highly vulnerable to climate change impacts. The Country Index scales vulnerability from 0 to 1, with 0 being least and 1 most vulnerable. With a vulnerability score of 0.536, Uganda is the 32nd most vulnerable nation globally (Notre Dame Global Adaptation Initiative, 2024). Rural populations are disproportionately affected due to their heavy reliance on climate-sensitive livelihoods, widespread poverty, and limited adaptive capacity, all of which heighten their vulnerability to climate risks.

Livelihood vulnerability to climate impacts and risk in GVL communities varies widely, even for people within a single community. This is largely attributed to the differences in exposure levels to hazards. Both Kisoro and Kasese are hilly areas, meaning that even neighbouring households can face different exposure risks: those living downhill are more exposed to mudslides than their upland neighbours. Moreover, structural differences in how communities access key resources (e.g., land), poverty levels, and the level of reliance on climate-sensitive resources among social and demographic groups all significantly affect their vulnerability levels. These important differences in exposure result in highly localized and context-dependent vulnerability levels for these regions.

For example, the high participation of women in climate-sensitive sectors, such as community and household gardens, crop farming, and utilization of ecosystem services, exposes them to hunger, while they bear the responsibility of feeding their families. The high vulnerability of the Indigenous Batwa in Kisoro is due to their continued marginalization, which limits their access to key resources such as agricultural land. Following the gazetting of protected areas, the Batwa's and other Indigenous Peoples' historical hunting and gathering livelihoods were restricted or halted entirely, and some were rendered landless, thus contributing to their historical vulnerability.

5.0 Recommendations for Climate Adaptation in the GVL

5.1 Climate Adaptation Policy Context

The Government of Uganda has mainstreamed climate resilience across several national planning and strategic documents and policies. Among others, this is particularly demonstrated in Vision 2040, the national adaptation plan (NAP) for agriculture framework, the nationally determined contributions (NDCs), the NAP roadmap, and the National Climate Change Policy.

Uganda submitted its intended NDCs in 2015, which became an official NDC in 2016 before being revised in 2022, with the third revision process initiated in 2025. The priorities of the NDCs are to reduce vulnerability and address adaptation across seven key sectors: i) agriculture and livestock, ii) forestry, iii) infrastructure, iv) water, v) energy, vi) health, and vii) disaster risk management.

The country also drew lessons from their National Adaptation Programme of Action (2007) in starting to develop a NAP in 2015 and in launching a NAP roadmap in 2017. Parallel to the roadmap, Uganda engaged in the development of sector-based adaptation planning to guide long-term adaptation and resilience strategies for the sectors most affected by climate change. This led to the completion of a NAP for agriculture in 2018. Supported by the United Nations Development Programme and the Food and Agricultural Organization of the United Nations, the program for this sectoral NAP aims to build capacities at national and subnational levels for gender-responsive climate change adaptation throughout the agriculture sector (United Nations Development Programme, Climate Change Adaptation, 2020). Two more sectoral NAPs were developed for health and for water, sanitation, and hygiene in 2024 and 2026, respectively.

Uganda adopted its third National Development Plan for the period 2020/21–2024/25, which prioritizes enhancing resilience across the following areas: agriculture, water resources, forestry and land management, energy, health, disaster preparedness, fisheries, tourism, and research and knowledge management.

Other key national strategies, plans, policies, and legislation in which climate adaptation work has been mainstreamed in Uganda include, but are not limited to, the following:

- Disaster Preparedness and Management Policy (2010)
- Strategic Investment Framework for Sustainable Land Management (2010–2020)
- Meteorology Act (2012)
- National Land Policy (2013)
- National Irrigation Policy (2017)
- National Environment Act (2019)
- Uganda's third National Action Plan on Women, Peace and Security (2021–2025)
- Uganda's third National Biodiversity Strategy and Action Plan (2025–2030).

5.2 Recommended NbS for Adaptation to Address Climate Change Impacts

With the impacts of climate change projected to continue affecting communities and ecosystems in the GVL, developing and implementing effective climate adaptation strategies is essential. To bolster the climate resilience of areas in and around Bwindi Impenetrable National Park, Rwenzori Mountains National Park, and Queen Elizabeth National Park, this section presents additional adaptation options based on the CAPA Initiative's comprehensive climate risk assessment. These options focus on NbS for adaptation, which work with nature to adapt to a changing climate while providing a range of socio-economic, health, and biodiversity co-benefits. These actions should be seen as part of a broader climate adaptation strategy and implemented alongside other adaptation and mitigation efforts to address climate change effectively.

Although there is evidence of the implementation of structured adaptation responses in the communities, further coordination is needed to ensure climate-resilient development and increase community resilience to projected climate risks at the CAPA sites. Planned NbS would ensure proactive adaptation that addresses specific climate impacts and risks, compared to spontaneous responses that are only reactive in nature. For example, including key governance structures and women-only groups is critical to implementing planned adaptation activities and increasing community and biodiversity resilience. Moreover, technological and infrastructure adaptation interventions should be mixed with behavioural change responses. The implementation of ecosystem-based adaptation responses that are supported by appropriate institutional frameworks is critical for creating climate-resilient communities.

Based on findings from the climate risk assessment, the NbS measures for adaptation in Table 4 were observed and co-identified in collaboration with local communities during the assessment process. These are recommended as interventions that can increase the resilience of communities and benefit ecosystems across sites in the GVL within Uganda, if implemented well.

Table 4. Observed and recommended NbS for climate adaptation for CAPA sites in the GVL to increase the resilience of communities and ecosystems

Observed and recommended NbS for climate adaptation	Climate hazards and impacts addressed	Sites for implementation
Tree planting in erosion-prone areas	Mudslides, flooding, and soil and slope erosion	Bwindi Impenetrable National Park
Restoring buffer zones between national parks and communities, with proper tree selection that provides foliage to gorillas and prevents wildlife from being attracted to communities	Increased human–wildlife conflict	
Climate-smart agroforestry (i.e., using species suitable for local ecosystems, with market linkages)	Dry spells and soil and slope erosion	
Riverbank stabilization by restoring and planting indigenous tree species	Ice cap melting, floods, and erosion	Rwenzori Mountains National Park
Alternative livelihoods (e.g., beekeeping) with market linkages and social inclusion considerations	Drought, increased dry spells, crop failure, and human–wildlife conflict	Rwenzori Mountains National Park and Queen Elizabeth National Park
Afforestation and reafforestation (e.g., planting drought-resistant trees such as teak)	Mudslides and droughts	
Invasive plant species removal	Biodiversity loss	Queen Elizabeth National Park
Restoration of steep slopes by planting indigenous species, including medicinal plants	Mudslides, flooding, and soil and slope erosion	
Awareness-raising on gender responsiveness and climate change adaptation	All the risks listed above	Bwindi Impenetrable National Park, Rwenzori Mountains National Park, and Queen Elizabeth National Park

Source: Fieldwork data.

5.3 Recommended Measures to Advance Gender-Responsive and Socially Inclusive Adaptation

Not everyone can participate equally in developing and implementing climate adaptation strategies and initiatives, due to varying levels of barriers that inhibit participation. For example, women, youth, and people with disabilities are significantly underrepresented and often lack confidence in their abilities to influence climate and biodiversity-related planning

and decision making due to limited knowledge on conservation and environmental issues. Moreover, Indigenous Batwa people, many of whom are dependent on ecosystems and natural resources for their livelihoods, are also underrepresented in natural resource and climate adaptation decision making. They have reported inadequate dialogue and consultations with them on the part of various government bodies on matters related to land ownership. They note that they are insufficiently considered in policies and plans that affect natural resource management within their communities.

To ensure that climate adaptation initiatives in the GVL are effective, inclusive, and sustainable, deliberate effort must be made to adopt a gender-responsive and socially inclusive approach to their design and implementation. Such an approach can help facilitate the fair and equitable distribution of benefits and improve the adaptive capacity of communities. This would further ensure that NbS are well-adapted to the people implementing and using the solutions. This section highlights key considerations for climate adaptation initiatives across CAPA sites in the GVL, drawing on lessons learned and insights from the integrated climate risk assessment.

Box 4. Barriers to meaningful participation in climate adaptation strategies

Active participation and leadership in decision making by women and underrepresented groups are crucial for effective and inclusive environmental and natural governance. Equitable governance and inclusion of stakeholders' voices strengthen the design and implementation of NbS for climate adaptation and ensure the measures are tailored to communities' actual needs, while avoiding exacerbating existing inequalities. Moreover, there is a growing evidence base that climate adaptation projects that incorporate gender considerations into their design are more effective (Dazé & Terton, 2021).

Across the GVL, there is low participation of women in natural resource-related governance bodies, despite a 30% quota in place for their representation in both Kasese and Kisoro. The Indigenous Batwa also have low participation rates even in community meetings, arising from their historical marginalization from conservation and natural resource management.

Cultural and community norms shaped by a patriarchal system ensure restricted opportunities for women and underrepresented groups, including limited land ownership, education, and associated lack of leadership capacity. Cultural influence, furthermore, mutes women's voices: it is difficult for them to participate in decision making when it is reported that many women fear speaking in the same space as men, even when their ideas are better.

The widespread presence of women-only and women-led groups and community-based organizations in the GVL may contribute to the empowerment of women in decision-making spaces beyond these livelihood-focused groups. Their meaningful participation in adaptation governance is crucial for addressing environmental challenges and contributing to a more just and sustainable future for all, regardless of gender (Balakrishnan, 2023).

Three key pillars to advance gender-responsive and socially inclusive adaptation were considered, which represent the CAPA Initiative's areas of focus for addressing gender and social barriers to promote GESI in NbS for adaptation outcomes. The selection of these pillars is based on recent studies that indicated these areas as the most salient for achieving equitable outcomes in NbS for adaptation (Caswell & Jang, 2024; Dazé & Terton, 2021). Table 5 outlines the main gaps identified for each key pillar, along with recommendations for the GVL landscape.

Table 5. Recommended measures to advance gender-responsive and socially inclusive climate adaptation, categorized into three focal areas

Key pillars	Gaps	Recommendations
Recognizing conservation and adaptation needs and capacities	Lack of integrated, structured, and proactive NbS for climate adaptation in communities and protected areas that are gender responsive	**1.1**: Implement adaptation responses that address short-term livelihood needs, based on current vulnerabilities of women in communities, while promoting the implementation of long-term measures that address near-term climate risk (at 1.5°C GWL)[2] in project sites to increase communities' and biodiversity's resilience. For example, implement mixed NbS such as tree planting coupled with invasive species removal, while promoting immediate community gardens to address growing food challenges in communities.
	Lack of key stakeholders' and communities' technical capacity to implement NbS for climate adaptation	**1.2**: Build capacity for leadership and provide training opportunities for women and underrepresented groups to enhance their knowledge, skills, and access to resources that increase household- and community-level resilience to current and future climate impacts.
Gender-equitable participation and influence in conservation and adaptation decision making	Lack of or limited community-based, GESI-responsive structures that support the implementation of NbS for climate adaptation to foster climate resilience	**2.1**: Revive, where they exist, and/or create new community-based structures that promote women's participation in conservation and management decision making for climate adaptation, to stimulate participation and break down barriers that limit women's participation. Such structures include the creation of women-only groups (for sites that do not already have these structures) or strengthening existing ones by integrating NbS for climate adaptation and livelihoods. This should be supported by activities such as awareness-raising in communities tailored to both men and women. Where women are in lower-level positions, facilitate their upward mobility in leadership.

[2] Many parts of Africa are expected to reach 1.5°C warming by the mid-2030s.

Key pillars	Gaps	Recommendations
		Where women already participate and are present at meetings, work with local leaders to ensure they understand the importance of women's input, choices, needs, and goals and how these are linked to the success and sustainability of NbS to be implemented.
	Lack of women's participation in key decision-making processes on conservation and natural resources management	**2.2**: Strengthen governance structures at the community, local government, and protected area governance levels for women's participation in conservation and management of natural resources and protected areas, through training, mentorship, capacity building, and reviewing existing management plans to make them GESI compliant. Where they do not exist, empower stakeholders in local government and communities who propose community bylaws to incorporate GESI issues. Where they do exist, support the review and establishment of such bylaws, and ensure women and underrepresented groups have formal roles in NbS governance structures and resource management committees.[3]
		2.3: Deliberately target and include underrepresented groups in the implementation of NbS for climate adaptation, including by raising the awareness of key stakeholders through training on why and how to incorporate these underrepresented groups. For example, protected area management authorities such as the Uganda Wildlife Authority can receive training on the importance of including underrepresented groups in conservation, and protected area and natural resource management. It is crucial that they understand what GESI entails, and its implications for the success or failure of NbS for climate adaptation.

[3] Note: These gaps provide an opportunity to develop and implement NbS-specific governance structures, especially at the community level, to complement existing governance structures such as Forest Management Committees and Village Environment Management Committees.

Key pillars	Gaps	Recommendations
Closing institutional gender gaps in conservation and adaptation policies and practices	Limited inclusion of women in institutional processes in conservation and protected area management	**3.1**: Develop GESI modules in which key stakeholders, including protected area managers and authorities, work together with community-based organizations to produce gender inclusion strategies with pragmatic approaches to increase GESI in policy and practice. GESI plans must be translated into practice through collaboration with traditional leaders and communities to promote the acceptance of gender transformation and to minimize resistance to change.
		3.2: Deliberately and proactively include gender, equity, and the voices of underrepresented groups in National Park management plans and strategies. The CAPA sites that are renewing their general management plans can incorporate GESI while also including pragmatic approaches and commitments to achieving GESI. Where provisions are already in place, such as quotas for participation in GVL management committees, collaborate with local government to raise their political will and commitment.
		3.3: Create gender operationalization frameworks that are sensitive to the gender dynamics, power, and political conditions of different communities. "Sensitive operationalization frameworks" imply that they allow for interventions to be smooth and received with little or no resistance as they attempt to usher in a gender-responsive, equity, and equality-based order in predominantly patriarchal systems.
	Lack of monitoring and evaluation frameworks for tracking NbS for climate adaptation and women's participation	**3.4**: Establish a monitoring, evaluation, and learning framework with performance indicators to track the progress on GESI, conflicts, and governance of the implemented activities to assess their effectiveness in addressing the key identified gaps.

Source: Fieldwork data.

References

Balakrishnan, R. (2023). Grassroots women's networks and climate adaptation governance in agrarian concession landscapes. *Journal of Gender, Agriculture and Environmental Studies*, 14(2), 112–128.

Caswell, C., & Jang, N. (2024). *Mainstreaming gender equality and social inclusion in nature-based solutions for climate change adaptation.* Nature for Climate Adaptation Initiative and International Institute for Sustainable Development. https://www.iisd.org/system/files/2024-01/gender-equality-social-inclusion-nature-based-solutions.pdf

Climate Change Knowledge Portal. (2026). *Uganda—Country overview*. World Bank. https://climateknowledgeportal.worldbank.org/country/uganda

Dazé, A., & Terton, A. (2021). *Toward gender responsive ecosystem-based adaptation: Why it's needed and how to get there*. Deutsche Gesellschaft für Internationale Zusammenarbeit and International Institute for Sustainable Development. https://www.adaptationcommunity.net/wp-content/uploads/2021/07/Toward-gender-responsive-EbA.pdf

Giorgi, F., Jones, C., & Asrar, G. R. (2009). Addressing climate information needs at the regional level: The COordinated Regional Climate Downscaling EXperiment (CORDEX). *WMO Bulletin*, 58(3), 175–183.

Greater Virunga Transboundary Collaboration. (2015). *Greater Virunga Transboundary Collaboration Treaty on Wildlife Conservation and Tourism*. https://greatervirunga.org/wp-content/uploads/2023/12/GVTC-Treaty-30-Oct-2015.pdf

Greater Virunga Transboundary Collaboration. (2024). *Terms of reference for the development of the FVL transboundary strategic plan 2024–2033*. https://greatervirunga.org/wp-content/uploads/2023/06/ToRs-for-development-of-GVL-transboundary-strategic-plan-May-26-2023.pdf

Gutiérrez, J. M., Jones, R. G., Narisma, G. T., Alves, L. M., Amjad, M., Gorodetskaya, I. V., Grose, M., Browne Klutse, N. A., Krakovska, S., Li, J., Martínez-Castro, D., Mearns, L. O., Mernild, S. H., Ngo-Duc, T., van den Hurk, B., & Yoon, J.-H., Iturbide, M., Jamero, M. L. P., Vanvyve, É., … Osima, S. (2023). Atlas. In V. Masson-Delmotte et al. (Eds.), *Climate change 2021 – The physical science basis: Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1927–2058). Cambridge University Press. https://doi.org/10.1017/9781009157896.021

Hersbach, H., Bell, B., Berrisford, P., Hirahara, S., Horányi, A., Muñoz-Sabater, J., Nicolas, J., Peubey, C., Radu, R., Schepers, D., Simmons, A., Soci, C., Abdalla, S., Abellan, X., Balsamo, G., Bechtold, P., Biavati, G., Bidlot, J., Bonavita, M., … Thépaut, J.-N. (2020). The ERA5 global reanalysis. *Quarterly Journal of the Royal Meteorological Society, 146*(730), 1999–2049. https://doi.org/10.1002/qj.3803

Intergovernmental Panel on Climate Change. (n.d.). *IPCC WGI Interactive Atlas: Regional synthesis.* https://interactive-atlas.ipcc.ch/regional-synthesis#eyJ0eXBlIjoiQ0lEIiwic2VsZWN0ZWRJbmRleCI6Im1lYW5fYWlyX3RlbXBlcmF0dXJlIiwic2VsZWN0ZWRWYXJpYWJsZSI6ImNvbmZpZGVuY2UiLCJzZWxlY3RlZENvdW50cnkiOiJHSUMiLCJtb2RlIjoiTUFQIiwiY29tbW9ucyI6eyJsYXQiOjk3NzIsImxuZyI6NDAwNjkyLCJ6b29tIjo0LCJwcm9qIjoiRVBTRzo1NDAzMCIsIm1vZGUiOiJjb21wbGV0ZV9hdGxhcyJ9fQ==

Intergovernmental Panel on Climate Change. (2023). Annex I: Glossary. In A. Reisinger, D. Cammarano, A. Fischlin, J. S. Fuglestvedt, G. Hansen, Y. Jung, C. Ludden, V. Masson-Delmotte, R. Matthews, J. B. K. Mintenbeck, D. J. Orendain, A. Pirani, E. Poloczanska, & J. Romero (Eds.), *Climate change 2023: Synthesis report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 119–130) [Core Writing Team, H. Lee and J. Romero (eds.)]. https://www.ipcc.ch/report/ar6/syr/

International Organization for Migration Uganda. (2024). *Uganda Multi-Hazard Infographic, April 2024.* https://uganda.iom.int/sites/g/files/tmzbdl1376/files/documents/2024-06/4-iom_uganda_multi-hazard_infographic_april_2024.pdf

Jang, N., Tablada, S., Vasquez, M., Surya, G., Rathbone, V., Jones, K., & Elsen, P. (2025). *Climate risk profile: Belize* [Climate Adaptation and Protected Area Initiative report]. International Institute for Sustainable Development. https://www.iisd.org/publications/report/belize-climate-risk-profile

Kenfack, C. E. (2013). *The Virunga landscape* (Brief no. 18). Center for International Forestry Research and World Agroforestry. https://www.cifor-icraf.org/publications/pdf_files/infobrief/4087-cobambrief.pdf

Notre Dame Global Adaptation Initiative. (2024). *Country index technical report.* https://gain.nd.edu/our-work/country-index/rankings/

Plumptre, A. J., Behangana, M., Davenport, T. R., Kahindo, C., Kityo, R., Ndomba, E., Nkuutu, D., Owiunji, I., Ssegawa, P., & Eilu, G. (2007). The biodiversity of the Albertine Rift. *Biological Conservation, 134*(2), 178–194. https://doi.org/10.1016/j.biocon.2006.08.021

Uganda Bureau of Statistics. (2020). *Statistical abstract.* https://www.ubos.org/wp-content/uploads/publications/11_2020STATISTICAL__ABSTRACT_2020.pdf

Uganda Wildlife Authority. (2014). *General management plan Bwindi Impenetrable National Park 2014–2024.* Ministry of Wildlife.

United Nations Development Programme, Climate Change Adaptation. (2020). *Experiences from Uganda's National Adaptation Plans' process*. https://www.adaptation-undp.org/experiences-ugandas-national-adaptation-plans-process

United Nations Environment Programme. (2022). *Proceedings of the United Nations Environment Assembly at its resumed fifth session* (UNEP/EA.5/28). UN Digital Library. https://digitallibrary.un.org/record/3971487

United Nations High Commissioner for Refugees [UNHCR]. (2022). *Global report 2022.* UNHCR. https://www.unhcr.org/sites/default/files/2023-07/2305336E_UNHCR-AR-2022_web_V3.pdf

United Nations Office for the Coordination of Humanitarian Affairs. (2014). *Uganda: Kasese floods, DREF operation n° MDRUG033, Preliminary final report.* International Federation of Red Cross and Red Crescent Societies. https://reliefweb.int/report/uganda/uganda-kasese-floods-dref-operation-n-mdrug033-preliminary-final-report

United Nations Office for the Coordination of Humanitarian Affairs. (2022). *Uganda: Floods and landslides – Sep 2021.* https://reliefweb.int/disaster/fl-2021-000153-uga

United Nations Office for the Coordination of Humanitarian Affairs. (2023). *Uganda: Floods – Jul 2022.* https://reliefweb.int/disaster/fl-2022-000275-uga

United Nations Office for the Coordination of Humanitarian Affairs. (2024). *Uganda: Floods and landslides – May 2020.* https://reliefweb.int/disaster/fl-2020-000132-uga

United Nations Office for the Coordination of Humanitarian Affairs. (2025). *Uganda: Floods – May 2024.* https://reliefweb.int/disaster/fl-2024-000075-uga

United Nations Women. (2022). *Situation report on Kisoro floods* (In Brief). Women, Peace and Security and Humanitarian Action. https://africa.unwomen.org/sites/default/files/2022-09/WPHSA_Kisoro%20Floods%20Sit%20Brief_0.pdf

World Wildlife Fund. (2021). *The Greater Virunga Landscape: Climate change vulnerability and adaptation assessment for GVL* (Fact Sheet). WWF Africa Climate Change Adaptation Initiative. https://wwfafrica.awsassets.panda.org/downloads/factsheet---climate-change-vulnerability-and-adaptation-assessment-for-gvl.pdf

Appendix A.

Table A1. Future climate projections in the Greater Virunga Landscape under four global warming level scenarios and respective timelines, relative to 1985–2005 baseline

Site	Global warming level	Temperature trends	Rainfall trends	Extreme rainfall events	Dryness
Kisoro	1.5°C	↑ + 6.4% mean temperature + 4.7% maximum temperature	↓ + 2.6% rainfall	↑ + 10.4% maximum 1-day rain + 8.6% maximum 5-day rain	↑ + 2.5 consecutive dry days
	2°C	↑ + 9.6% mean temperature + 7.2% maximum temperature	↓ + 2.5% rainfall	↑ + 15.8% maximum 1-day rain + 10.9% maximum 5-day rain	↓ + 1.7 consecutive dry days
	3°C	↑ + 16.4% mean temperature + 12.3% maximum temperature	↓ + 1.1% rainfall	↓ + 22.7% maximum 1-day rain + 14.3% maximum 5-day rain	↑ + 5.1 consecutive dry days
	4°C	↑ + 22.3% mean temperature + 16.5% maximum temperature + 0.2 days >35°C	↑ + 2.9% rainfall	↑ + 42.6% maximum 1-day rain + 26.5% maximum 5-day rain	↓ + 2.2 consecutive dry days

Site	Global warming level	Temperature trends	Rainfall trends	Extreme rainfall events	Dryness
Kasese and Rubirizi	1.5°C	↑ + 5.8% mean temperature + 4.7% maximum temperature	↓ – 3% rainfall	↑ + 8.9% maximum 1-day rain + 5.3% maximum 5-day rain	↑ + 0.8 consecutive dry days
	2°C	↑ + 8.6% mean temperature + 6.8% maximum temperature	↓ – 3.3% rainfall	↑ + 11.5% maximum 1-day rain + 6.1% maximum 5-day rain	↑ + 1.4 consecutive dry days
	3°C	↑ + 14.7% mean temperature + 11.5% maximum temperature + 0.2 days >35°C	↓ – 5.5% rainfall	↑ + 22.9% maximum 1-day rain + 11.3% maximum 5-day rain	↑ + 1.5 consecutive dry days
	4°C	↑ + 20.3% mean temperature + 15.5% maximum temperature + 1.6 days >35°C	↓ – 6.3% rainfall	↑ + 35.3% maximum 1-day rain + 17% maximum 5-day rain	↓ + 1.3 consecutive dry days

Source: Intergovernmental Panel on Climate Change, n.d.; Giorgi et al., 2009; Gutiérrez et al., 2023.

Climate Adaptation
and Protected Areas
Initiative